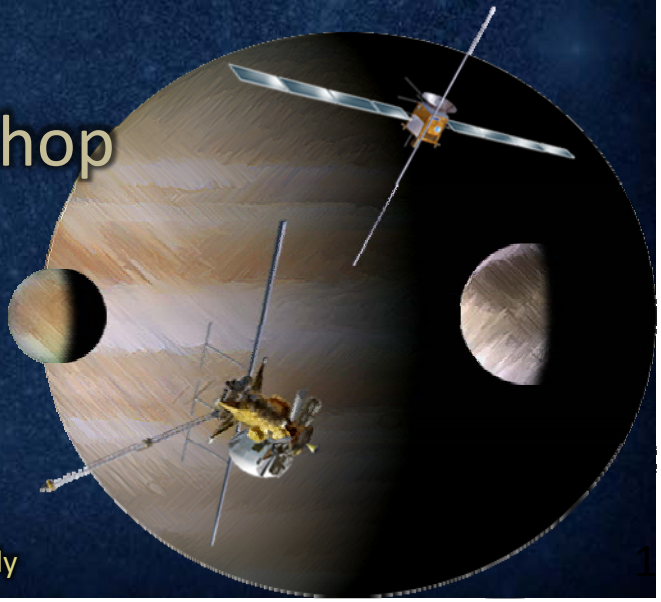
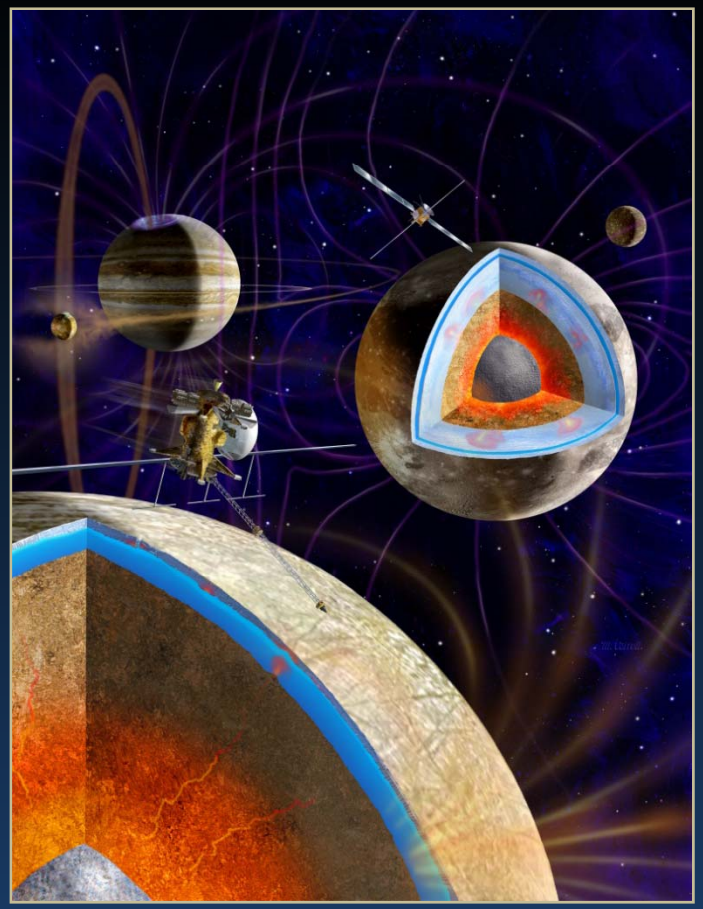
Europa Jupiter System Mission

Karla B. Clark
Thomas J. Magner
Christian Erd

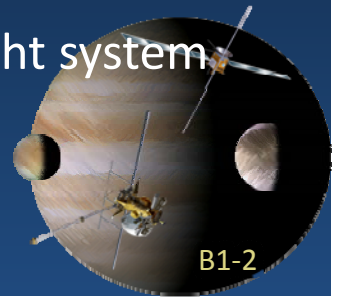
EJSM Instrument Workshop
July 27 – 29, 2010



Europa Jupiter System Mission



- NASA and ESA: Shared mission leadership
- Independently launched and operated flight systems with complementary payloads
  - NASA-led Jupiter Europa Orbiter (JEO)
  - ESA-led Jupiter Ganymede Orbiter (JGO)
- Complementary science and payloads
  - JEO concentrates on Europa and Io
  - JGO concentrates on Ganymede and Callisto
  - Both perform Jupiter System Science
  - Synergistic overlap
  - ~11 instruments on each flight system

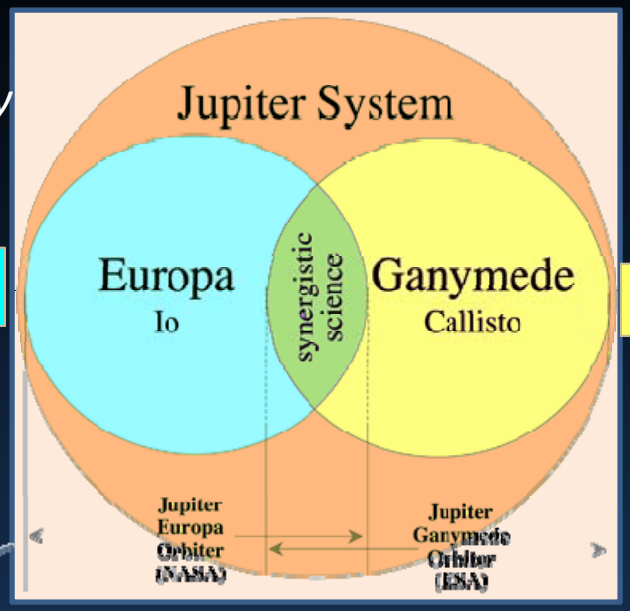


EJSM Theme: The Emergence of Habitable Worlds Around Gas Giants

Explore the Jupiter system as an archetype for gas giants.

Explore Europa to investigate its habitability

Characterize Ganymede as a planetary object including its potential habitability



NASA Jupiter Europa Orbiter
(artist's conception)

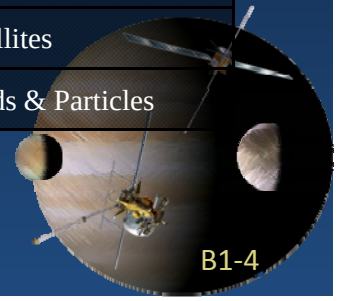
ESA Jupiter Ganymede Orbiter
(artist's conception)

Joint Science Definition Team (JSDT)

(page 1 of 2)

Member	Affiliation	Expertise
Ron Greeley—Co-Chair	ASU	Europa
Bob Pappalardo—PS	JPL	Europa/Jupiter System
Ariel Anbar	ASU	Astrobiology
Bruce Bills	GSFC	Geophysics
Diana Blaney	JPL	Composition
Don Blankenship	UTA	Radar/Geophysics
Phil Christensen	ASU	Composition
Brad Dalton	JPL	Composition
Jody Deming	UW	Astrobiology
Rick Greenberg	UA	Geophysics
Kevin Hand	JPL	Astrobiology
Amanda Hendrix	JPL	Satellites
Torrence Johnson	JPL	Jupiter System
Krishan Khurana	UCLA	Fields & Particles
Ralph Lorenz	APL	Satellites
Essam Marouf	San Jose State	Radio Science
Tom McCord	Bear Fight Ctr	Composition

Member	Affiliation	Expertise
Melissa McGrath	MSFC	Satellites
Amy Simon-Miller	NASA GSFC	Jupiter Atmosphere
Bill Moore	UCLA	Geophysics
Jeff Moore	ARC	Geology
Francis Nimmo	UCSC	Geophysics
Chris Paranicas	APL	Fields & Particles
Louise Prockter	APL	Geology
Jerry Schubert	UCLA	Jupiter
David Senske	JPL	Satellites
Adam Showman	UA	Jupiter
Mark Showalter	SETI Inst	Rings
Mitch Sogin	Marine Bio Lab	Astrobiology
Christophe Sotin	JPL	Satellites
John Spencer	SWRI	Satellites
Elizabeth Turtle	APL	Satellites
Hunter Waite	SWRI	Fields & Particles

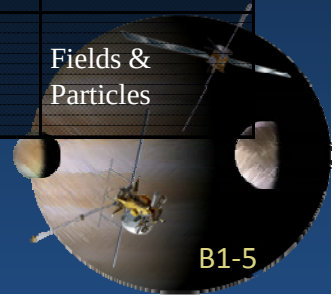


Joint Science Definition Team (JSDT)

(page 2 of 2)

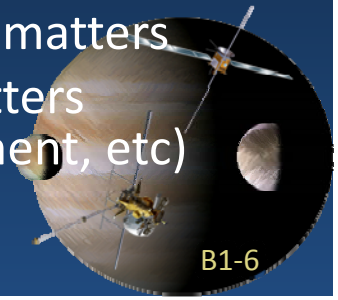
Member	Affiliation	Expertise
EU JJSDT Membership		
Jean-Pierre Lebreton—Co-Chair	European Space Agency	Plasma Physics
Olga Prieto-Ballasteros	INTA	Astrobiology
Michel Blanc	École Polytechnique	Magnetospheres
Emma Bunce	University of Leicester	Fields and Particles
Andrew Coates	University of College London	Fields and Particles
Angioletta Coradini	Institute for Interplanetary Space Physics	Composition
Athena Coustenis	Paris-Meudon Observatory	Jupiter System
Michele Dougherty	Imperial College	Fields & Particles
Pierre Drossart	Paris Observatory	Jupiter
Leigh Fletcher	Oxford University	Jupiter Atmospheres
Olivier Grasset	University of Nantes	Geology
Hauke Hubmann	DLR	Geophysics
Ralf Jaumann	DLR	Satellites
Norbert Krupp	Max Planck Institute	Fields & Particles

Member	Affiliation	Expertise
EU JJSDT Membership		
Dima Titov	Max Planck Institute/ESTEC	Jupiter System
Paolo Tortora	University of Bologna	Radio Science
Federico Tosi	Institute of Physics of Interplanetary Space	Composition
Tim Van Hoolst	Royal Observatory of Belgium	Satellites
Japan JJSDT Membership		
Masaki Fujimoto	Institute of Space and Astronautical Science/Japan Space Exploration Agency	Fields & Particles
Yasumasa Kasaba	Tohoku University	Fields & Particles
Sho Sasaki	National Astronomical Observatory of Japan	Satellites
Yukihiro Takahashi	Tohoku University	Jupiter
Takeshi Takashima	Institute of Space and Astronautical Science/Japan Space Exploration Agency	Fields & Particles

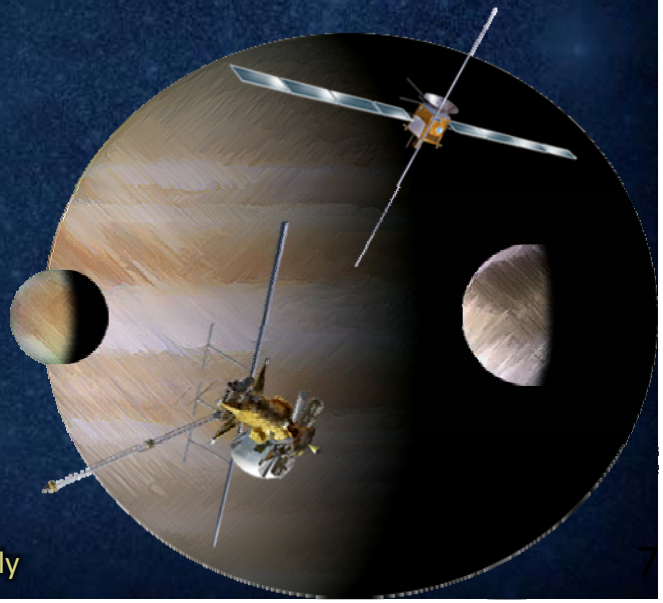


EJSM Governance Structure (NASA/ESA) Assumptions

- An MOU will be signed between NASA Headquarters and ESA detailing agreements
- Instruments
  - Coordinated AOs for all instruments
  - Joint NASA/ESA selection
  - Instruments will be provided by NASA for JGO
    - Must meet ESA/JGO technical requirements
  - Instruments will be provided by ESA member states for JEO
    - Must meet NASA/JEO technical requirements
- Reviews
  - ESA will provide non-voting members of the NASA JEO mission review board (SRB)
  - NASA will provide non-voting members of the ESA JGO mission review board
- Coordination
  - A JEO/JGO project board will coordinate project and scientific matters
  - A NASA Headquarters/ESA board will coordinate program matters (synergistic science objectives, launch dates, provided instrument, etc)

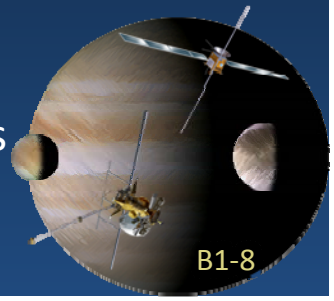


EJSM/JEO Mission Overview

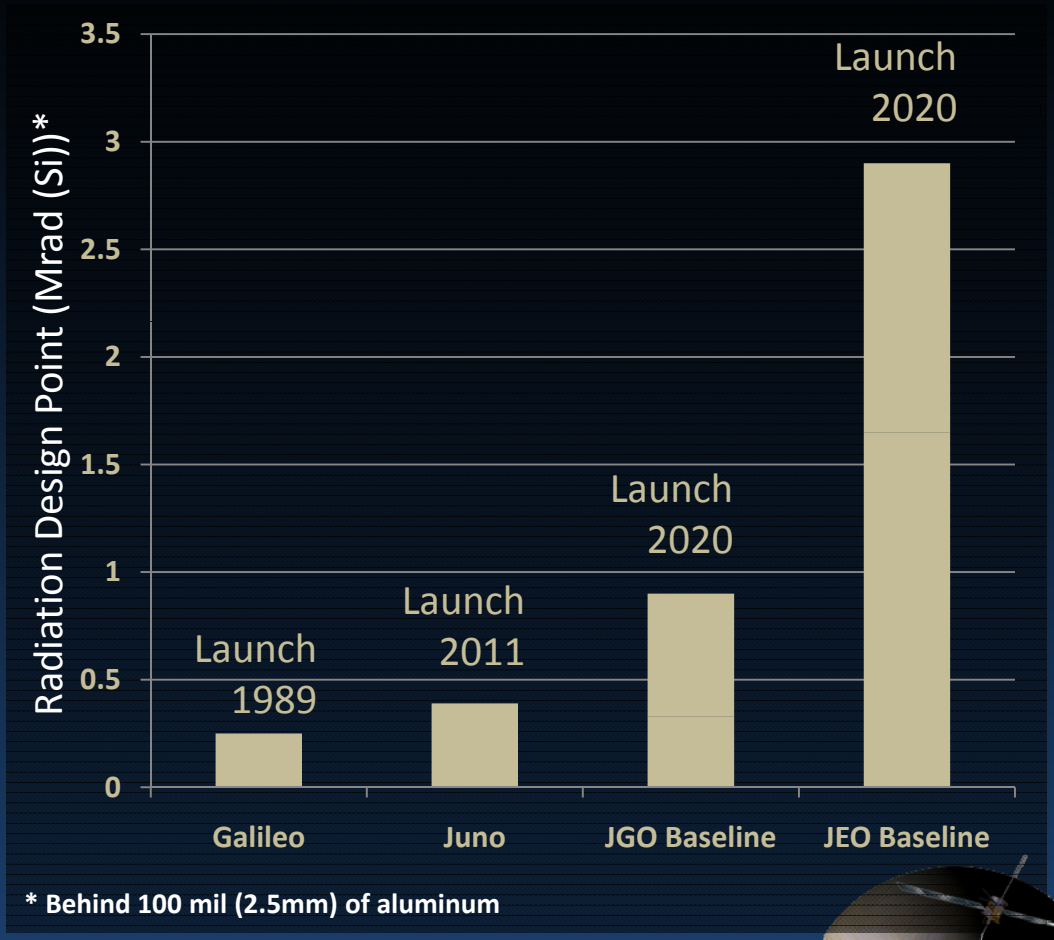


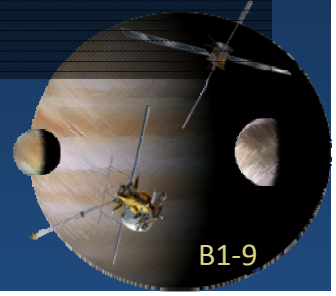
JEO Mission Concept Overview

- Objectives: Jupiter System, Europa
- Launch vehicle: Atlas V 551
- Power source: 5 MMRTG
- Mission timeline:
  - Launch: Nominally 2020
    - Uses 6-year Venus-Earth-Earth gravity assist trajectory
  - Jovian system tour phase: 30 months
    - Multiple satellite flybys: 4 Io, 6 Ganymede, 6 Europa, and 9 Callisto
  - Europa orbital phase: 9 months
  - End of prime mission: 2029
  - Spacecraft final disposition: Europa surface impact
- 11 Instruments, including radio science
- Optimized for science, cost, and risk
- Radiation design dose: 2.9 Mrad (behind 100 mils of Al)
  - Handled using a combination of rad-hard parts and tailored component shielding
  - Key rad-hard parts are available, with the required heritage
  - Team is developing and providing design information and approved parts list for prospective suppliers of components, including instruments

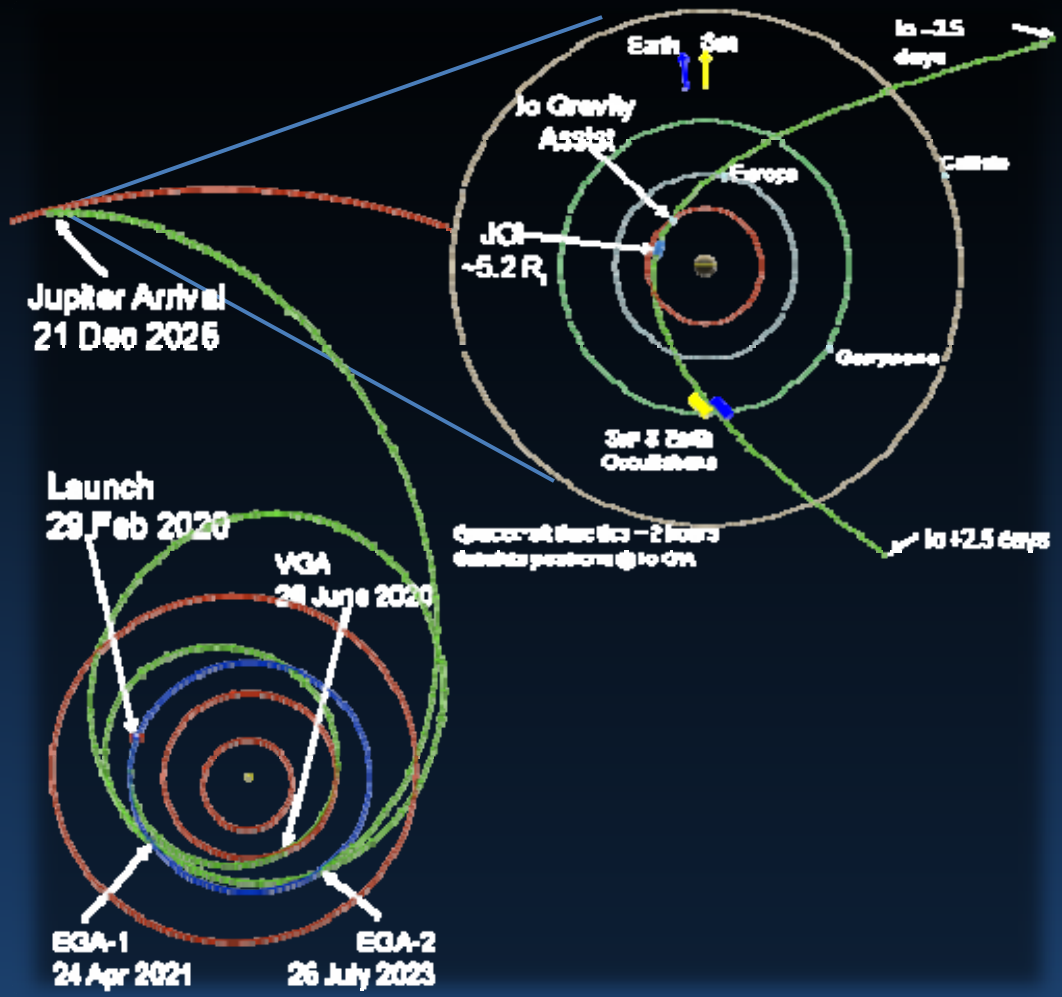


Mission Radiation Challenge

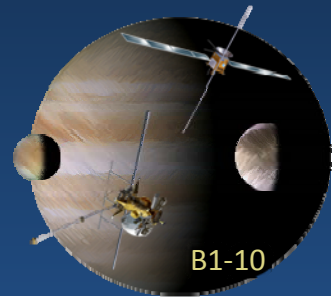




JEO Trajectory & Orbit Insertion Concept

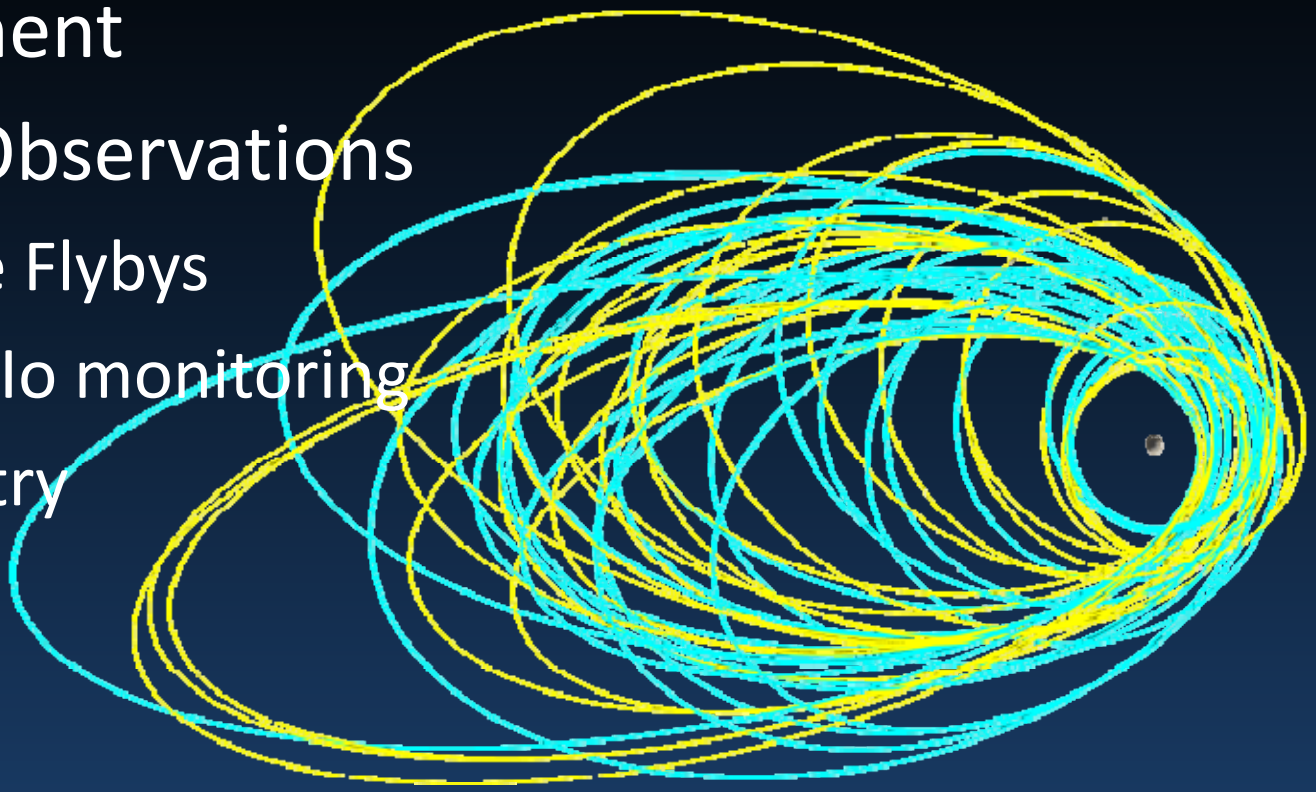


- Launch on Atlas V
- 4745 kg wet mass
- Venus-Earth-Earth Gravity Assist (VEEGA)
- Minimum range to Sun ≥ 0.7AU
- JOI date: 21 December 2025
- JOI range: 5.2 Rj
- 200-day initial orbit post-JOI
- Io gravity assist
- Science tour starts post JOI

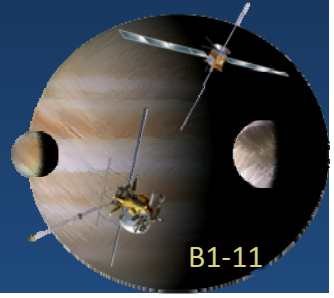


JEO Tour Design Drivers

- Radiation Environment
- Science Observations
  - Satellite Flybys
  - Jupiter/Io monitoring
  - Geometry
  - Lighting
- Duration

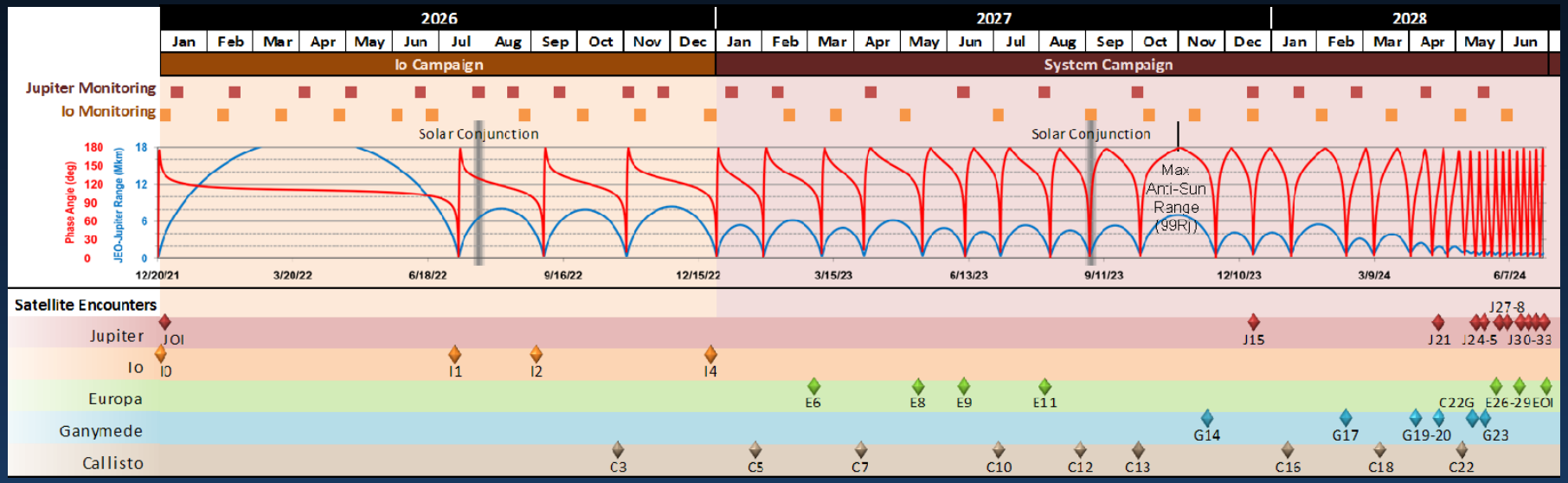


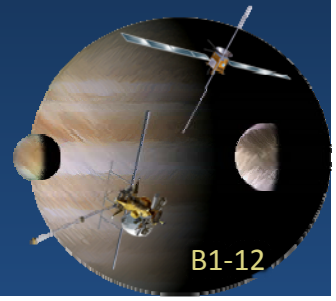
Tour design continues to evolve



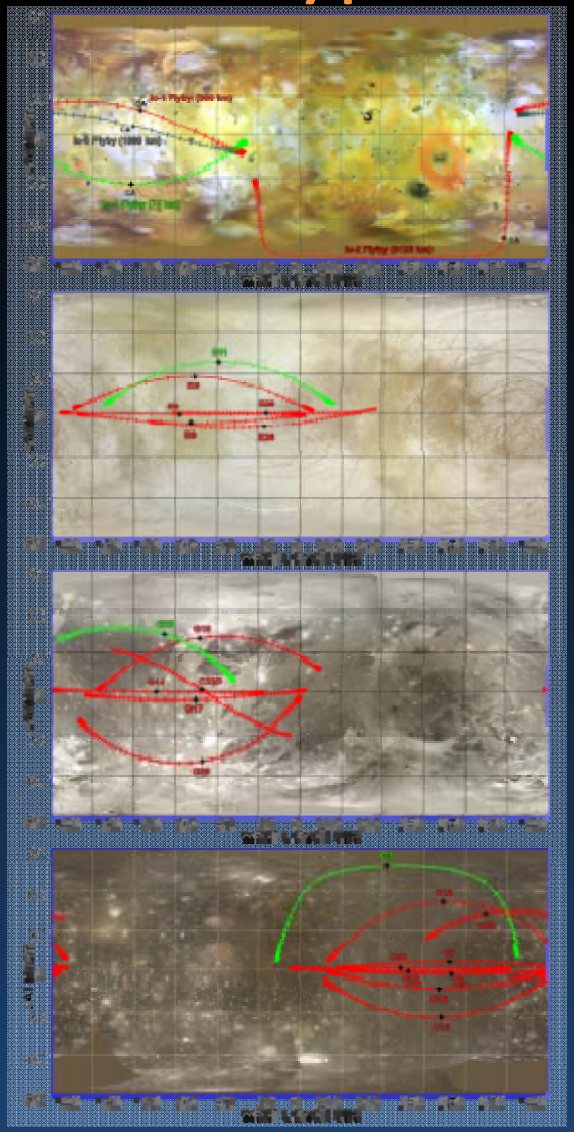
Baseline JEO Jovian Tour Phase

- Opportunities for sciences in the tour are many
  - Flybys, Io and Jupiter monitoring, etc
  - Varied conditions



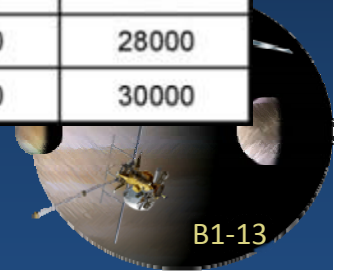


Typical JEO Tour Satellite Science



- Io: 3 flybys
  - Opportunities for imaging, IR spectroscopy, and altimetry
  - In situ analysis of extended atmosphere with INMS at 75 km
- Europa: 6 flybys
  - Radar and altimetry characterization and calibration
  - Imaging at up to 10–50 m resolution, NIR 250–1250 m
- Ganymede: 6 flybys
  - Radar sounding of grooved and dark terrains
  - Range of lats, lons for magnetosphere sampling
- Callisto: 9 flybys
  - High-latitude flyby for gravity field determination
  - Ocean characterization with magnetometer
  - Radar for subsurface structure of ancient cratered terrain

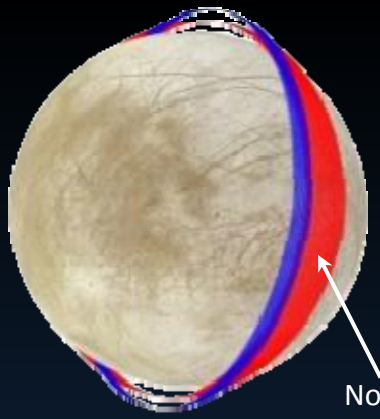
Satellite	≤1000m	≤200m	≤50m	≤10m	Length IPR (km)	Length LA (km)
Io	30%	20%	5%	-	1000	7400
Europa	60%	60%	15%	0.01%	6600	19000
Ganymede	50%	50%	10%	0.02%	17000	28000
Callisto	85%	75%	5%	0.01%	15000	30000

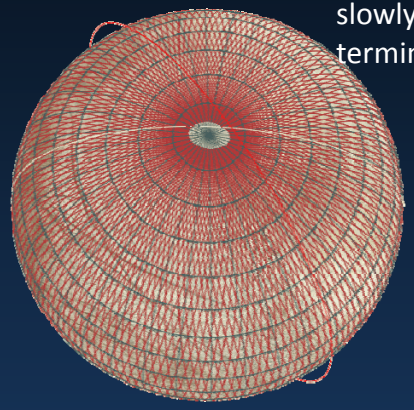


Notional JEO Europa Science Orbit

- 200 km altitude for early science in the first 28 days, then transition to a 100 km altitude
- Average orbit at ~2:30 pm LST
- Inclination selected to balance lighting and coverage
  - 95° to 100° (~85° N lat)
  - Orbit rotates 0.1 to 0.4 deg/day
- Ground track repeat cycle selected for ground track separation and global imaging coverage
  - Repeat cycle would be optimized when payloads are selected
  - Global coverage in 3 eurosols (~10 days) using every other orbit
  - Could be changed on orbit for small ΔV
- Orbit Characteristics:

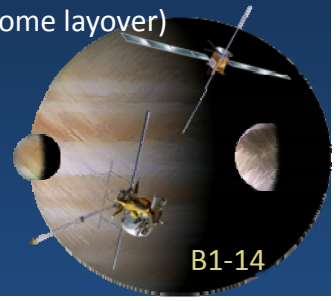
Orbit Altitude (km)	Period (min)	Occultation Dur (min)	Orbits Per Day	Ground Speed (km/s)
200	138	46 (33%)	10.4	1.1
100	126	47 (37%)	11.4	1.3





Groundtracks cover 95% of Europa surface

Poles could be imaged off-nadir (some layover)



Notional Europa Science Campaigns

JOI to EOI	Jul 2028	Aug 2028	Sep 2028	Oct 2028

Observing Strategies for Europa Campaigns 1-3

Always on: LA, MAG, PPI, TI, INMS (50%)

2-orbit ops scenario permits power/data rate equalization:

- Even orbits emphasize optical remote sensing:
- Odd orbits emphasize radar sounding to locate water

Targets collected with residual data volume

Satellite/Jupiter Science

Eng Assessment (6d)

1A | 1B

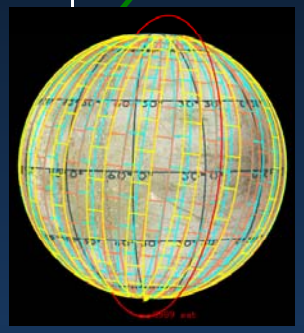
2A | 2B

3

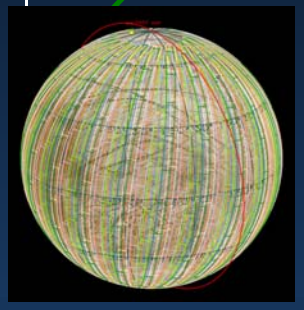
4

Initial Europa Orbit
Altitude: 200 km
Inclination: 95-100 deg (~85°N lat)
Lighting: 2:30 PM LST
Repeat: 4 eurosols

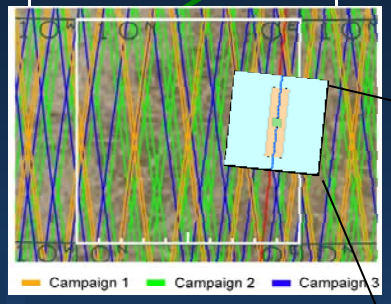
After Campaign 1
Altitude: 100 km
Repeat: 6 eurosols

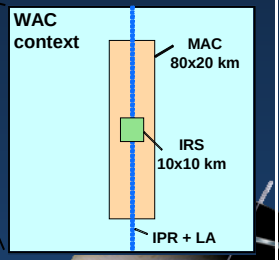


Global Framework
200 km altitude
(200 m/pixel WAC)
8 eurosols ≈ 28 days



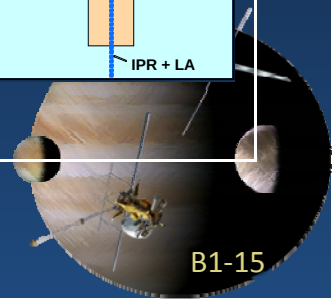
Regional Processes
100 km altitude
(100 m/pixel WAC)
12 eurosols ≈ 43 days





Targeted Processes
100 km altitude
8 eurosols ≈ 28 days

Europa Campaigns 1-3
total 99 days



Notional Europa Science Campaigns

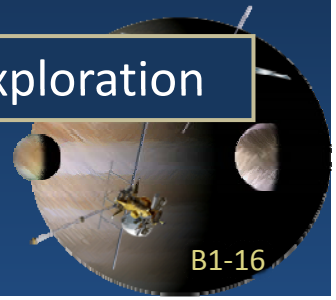
By end of Europa Campaign 3:

99 days orbital science
4 global maps
- 2 @ 200m Color + Stereo
- 2 @ 100m Stereo

730 imaging and radar targets
18 km profile spacing for LA and TI
35 km spacing for IPR and VIRIS
400 UVS stellar occultations
700 Gb data return

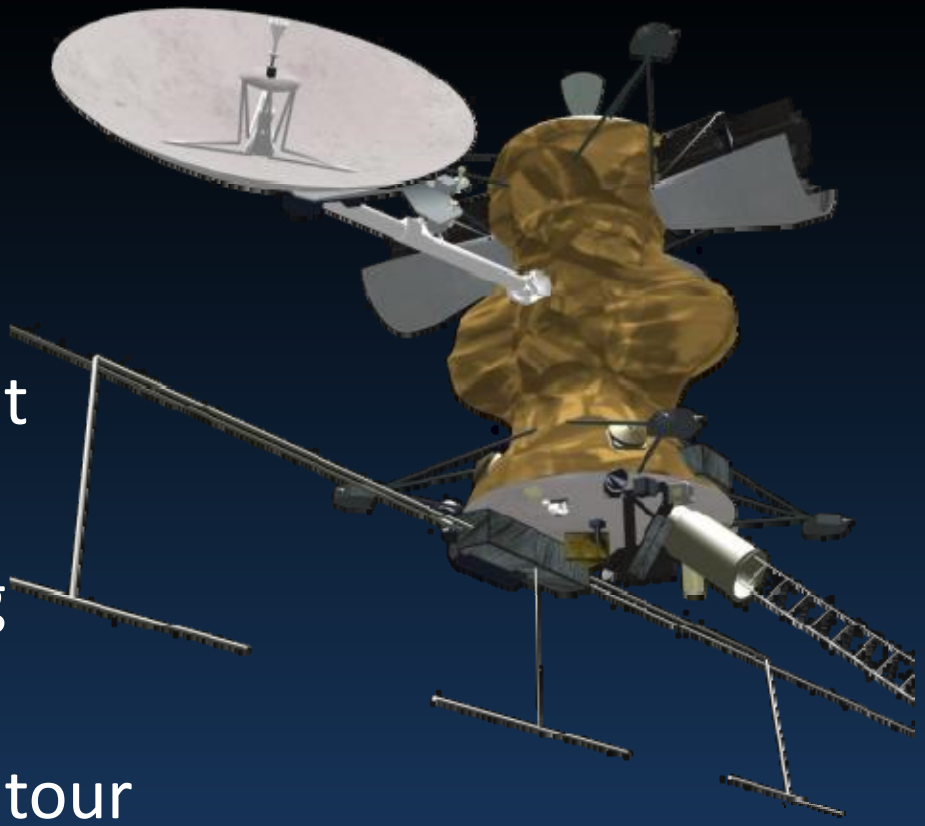
- Follow up on discoveries
- Finer global and regional grid of profiling observations (IPR, VIRIS, TI)
- Continue gravity, laser altimetry, and fields and particles measurements
- Additional coordinated target sets
  - Investigate new discoveries and priorities
  - Characterize candidate future landing sites
- Off-nadir NAC stereo images
- Lower altitude operations
- Monitor Io and Jupiter, 1 to 2 times per week

Extended time in Europa orbit allows additional investigations and exploration

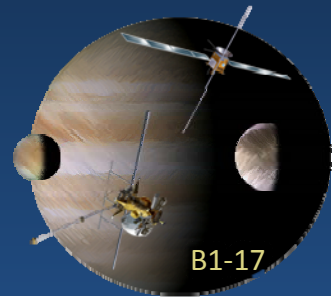


JEO Spacecraft Key Technical Drivers

- Venus fly-by
- Radiation
- Planetary Protection
- Nadir Pointed Instrument Pallet Module
- Real-time Science during Europa orbit
- 17 Gb storage for Jovian tour
- 1 Gb storage for Europa science



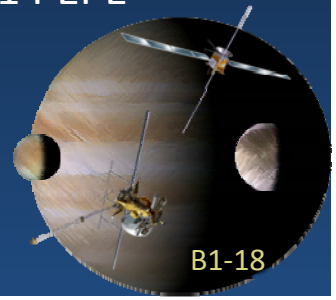
Artist's Rendering



JEO Model Payload

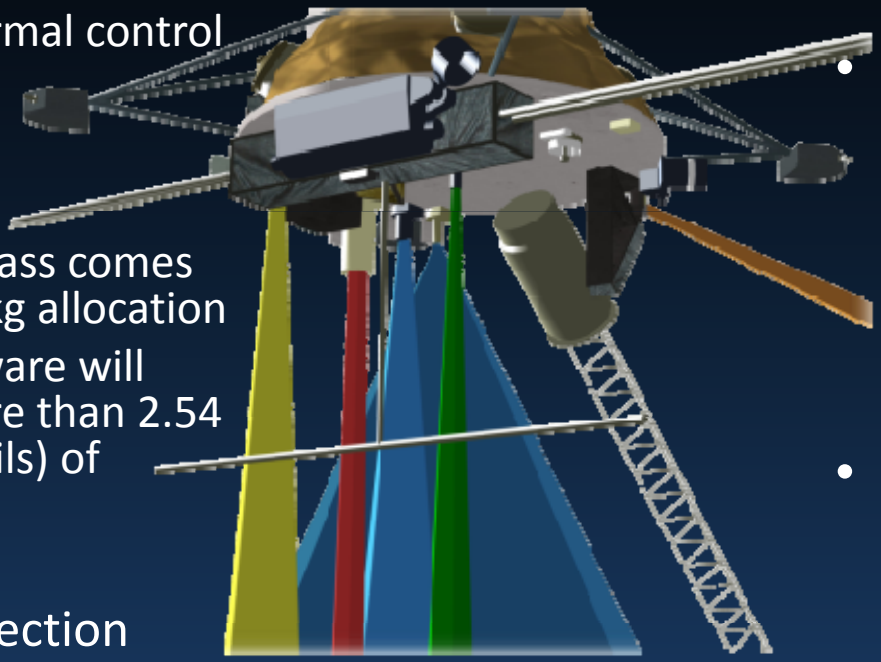
JEO Instrument	Similar Instruments
Radio Science	New Horizons USO, Cassini KaT
Laser Altimeter	MESSENGER MLA, NEAR NLR
Ice Penetrating Radar	MRO SHARAD, Mars Express MARSIS
VIS-IR Spectrometer	MRO CRISM, Chandrayaan MMM
UV Spectrometer	Cassini UVIS, New Horizons Alice
Ion & Neutral Mass Spectrometer	Rosetta ROSINA RTOF
Thermal Instrument	MRO MCS, LRO Diviner
Narrow-Angle Camera	New Horizons LORRI, LRO LROC
Camera Package	MRO MARCI, MESSENGER MDIS
Magnetometer	MESSENGER MAG, Galileo MAG
Particle and Plasma Instrument	New Horizons PEPSSI, Deep Space 1 PEPE

Used to size spacecraft and develop notional operations scenarios



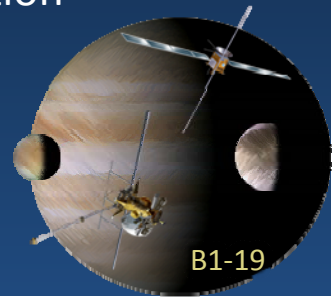
Notional Payload Design Drivers

- Thermal
  - Instruments provide own heating/cooling
  - Passive thermal control preferred
- Radiation
  - Shielding mass comes out of 165 kg allocation
  - Most hardware will require more than 2.54 mm (100 mils) of shielding
- Planetary Protection
  - Instruments must be sterilized



Artist's Rendering

- 165 kg total mass
  - Including Contingency
- 71 W average power
  - Data Collection & Transfer
  - Actuators
  - Thermal
  - Stand-by
- Pointing
  - S/C pointed Nadir during Europa science
  - Instruments must provide own articulation



Near-Term Timeline

- Completed JEO internal Mission Concept Peer Review, June 7-9
- Continuing JEO technical efforts on
  - APML, parts testing and evaluation
  - Core components identification (power converters, microprocessors, FPGAs/ASICs)
  - Shielding approach for sensors/detectors
  - System modeling
- This and other information presented over next few days
- Anticipate JEO Mission Phase A start, 2011
- Anticipate JEO Payload Announcement of Opportunity release, early 2011